

What we claim is:

1. In combination:

a permanent magnet turbogenerator/motor;

a repetitive axial motion machine driven by an electric motor supplied with electrical power by said permanent magnet turbogenerator/motor; and

a controller operably associated with said permanent magnet turbogenerator/motor and said repetitive axial motion machine to establish a variable frequency time profile for said electric motor of said repetitive axial motion machine, said controller utilizing repetitive axial motion machine cycle position data and historical data on the variable frequency versus repetitive axial motion machine cycle position profile to provide a substantially constant power level requirement for said permanent magnet turbogenerator/motor.

2. The combination of claim 1 wherein said variable frequency time profile is established by four control loops, one control loop providing a temperature safety limit, one control loop providing a speed safety limit, one control loop providing a power variation minimizing control based on instantaneous data and one providing power variation minimizing control based on historical data.

3. The combination of claim 2 wherein said controller includes;

a high frequency inverter synchronously connected to said permanent magnet turbogenerator/motor;

a low frequency load inverter operably connected to said electric motor driving said repetitive axial motion machine;

a direct current bus electrically connecting said high frequency inverter with said low frequency load inverter; and

8 a processor to control the frequency and voltage/current of said high frequency inverter
9 and said low frequency load inverter.

1 4. The combination of claim 3 wherein said control loop providing a power variation
2 minimizing control based on instantaneous data includes a first control loop to adjust fuel flow to
3 said permanent magnet turbogenerator/motor to match the power generated by said permanent
4 magnet turbogenerator/motor with the current power requirements of said electric motor, and a
5 second control loop to adjust said low frequency load inverter frequency so that said electric
6 motor power requirements match the current power generated by said permanent magnet
7 turbogenerator/motor

1 5. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well having axially moving and rotationally moving masses, and
3 said processor varies the frequency of said low frequency load inverter to accelerate and
4 decelerate said axially moving and rotationally moving masses of said pump-jack oil well to
5 control the power requirements of said electric motor driving said pump-jack oil well.

1 6. The combination of claim 5 wherein the frequency of said low frequency load inverter
2 is varied to minimize variations in the power requirements of said electric motor driving said
3 pump-jack oil well over the operating cycle of said pump-jack oil well.

1 7. The combination of claim 5 wherein the frequency of said low frequency load inverter
2 is established to match the oil pumping rate of said pump-jack oil well with the rate at which oil
3 seeps into the oil well.

1 8. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and said processor varies the instantaneous frequency of
3 said low frequency load inverter over the operating cycle of said pump-jack oil well.

1 9. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and said processor varies the instantaneous voltage of said
3 low frequency load inverter over the operating cycle of said pump-jack oil well.

1 10. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and said processor varies the instantaneous current of said
3 low frequency load inverter over the operating cycle of said pump-jack oil well.

1 11. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and said processor varies the frequency of said low
3 frequency load inverter over the operating cycle of said pump-jack oil well to reduce variations in
4 the power requirements of said electric motor driving said pump-jack oil well.

1 12. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and said processor varies the voltage or current of said low
3 frequency load inverter over the operating cycle of said pump-jack oil well to control the slip of
4 said electric motor driving said pump-jack oil well.

1 13. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and, over the operating cycle of said pump-jack oil well,
3 said processor controls the instantaneous pumping work performed by said pump-jack oil well
4 and the instantaneous pumping work being extracted from said pump-jack oil well.

1 14. The combination of claim 3 wherein said repetitive axial motion machine driven by an
2 electric motor is a pump-jack oil well, and said processor causes the total of instantaneous
3 pumping energy required or produced by said pump-jack oil well, and the instantaneous kinetic
4 energy extracted from or inserted into said pump-jack oil well, to be substantially constant over
5 the operating cycle of said pump-jack oil well.

1 15. In combination:

2 a permanent magnet turbogenerator/motor:

3 a plurality of repetitive axial motion machines each driven by an electric motor supplied
4 with electrical power by said permanent magnet turbogenerator/motor; and

5 a controller operably associated with said permanent magnet turbogenerator/motor and
6 said repetitive axial motion machine to establish a variable frequency time profile for said electric
7 motor of each of said plurality of repetitive axial motion machines, said controller utilizing
8 repetitive axial motion machine cycle position data and historical data on the variable frequency
9 versus repetitive axial motion machine cycle position profile of each of said plurality of repetitive
10 axial motion machines to provide a substantially constant power level requirement for said
11 permanent magnet turbogenerator/motor.

12 16. The combination of claim 15 wherein said variable frequency time profile is
13 established by four control loops, one control loop providing a temperature safety limit, one
14 control loop providing a speed safety limit, one control loop providing a power variation
15 minimizing control based on instantaneous data and one providing power variation minimizing
16 control based on historical data.

1 17. The combination of claim 16 wherein:

2 said plurality of repetitive axial motion machines each driven by an electric motor are a
3 plurality of pump-jack oil wells;

4 said controller includes a high frequency inverter synchronously connected to said
5 permanent magnet turbogenerator/motor, a low frequency load inverter operably connected to
6 said electric motor driving said pump-jack oil well, a direct current bus electrically connecting said
7 high frequency inverter with said low frequency load inverter, and a processor to control the

8 frequency and voltage/current of said high frequency inverter and said low frequency load
9 inverter; and

10 said control loop providing a power variation minimizing control based on instantaneous
11 data includes a first control loop to adjust fuel flow to said permanent magnet
12 turbogenerator/motor to match the power generated by said permanent magnet
13 turbogenerator/motor with the current power requirements of said plurality of pump-jack oil
14 well's electric motors, and a second control loop to adjust said low frequency load inverter
15 frequency so that the power requirements of said plurality of pump jack oil well's electric motors
16 match the current power generated by said permanent magnet turbogenerator/motor.

17 18. In combination:

18 a permanent magnet turbogenerator/motor including a permanent magnet
19 generator/motor, a compressor, and a gas turbine having a combustor;

20 at least one pump-jack oil well driven by an electric induction motor supplied with
21 electrical power by said permanent magnet turbogenerator/motor; and

22 a controller operably associated with said permanent magnet turbogenerator/motor and
23 said at least one pump-jack oil well to establish a variable frequency time profile for said electric
24 induction motor of said pump-jack oil well, said controller utilizing pump-jack oil well cycle
25 position data and historical data on the variable frequency versus pump-jack oil well cycle position
26 profile to provide a substantially constant power level requirement for said permanent magnet
27 turbogenerator/motor.

28 19. The combination of claim 18 wherein said controller includes a plurality of primary
29 control loops.

1 20. The combination of claim 19 wherein one of said primary control loops is a turbine
2 exhaust gas temperature control loop.

1 21. The combination of claim 19 wherein one of said primary control loops is a
2 turbogenerator speed control loop.

1 22. The combination of claim 19 wherein one of said primary control loops is a power
2 control loop.

1 23. The combination of claim 19 wherein said primary control loops include a turbine
2 exhaust gas temperature control loop and a turbogenerator speed control loop.

1 24. The combination of claim 19 wherein said primary control loops include a turbine
2 exhaust gas temperature control loop and a power control loop.

1 25. The combination of claim 19 wherein said primary control loops include a power
2 control loop and a turbogenerator speed control loop.

1 26. The combination of claim 19 wherein said primary control loops include a turbine
2 exhaust gas temperature control loop, a turbogenerator speed control loop, and a power control
3 loop.

1 27. The combination of claim 26 wherein said turbine exhaust gas temperature control
2 loop and said turbogenerator speed control loop command fuel input to the turbogenerator
3 combustor.

1 28. The combination of claim 27 and in addition a selector to select the minimum fuel
2 command from said turbine exhaust gas temperature control loop and said turbogenerator speed
3 control loop.

1 29. The combination of claim 26 wherein said controller additionally includes a
2 turbogenerator speed command control loop and a turbogenerator power command control loop.

1 30. The combination of claim 26 wherein said controller additionally includes a maximum
2 turbogenerator speed control loop and a maximum turbine exhaust gas temperature control loop.

1 31. The combination of claim 18 wherein said controller includes;
2 a high frequency inverter synchronously connected to said permanent magnet
3 turbogenerator/motor;
4 a low frequency load inverter operably connected to said electric motor driving said
5 repetitive axial motion machine;
6 a direct current bus electrically connecting said high frequency inverter with said low
7 frequency load inverter; and
8 a processor to control the frequency and voltage/current of said high frequency inverter
9 and said low frequency load inverter.

1 32. The combination of claim 31 wherein said processor includes a plurality of primary
2 control loops.

1 33. The combination of claim 32 wherein one of said primary control loops is a turbine
2 exhaust gas temperature control loop.

1 34. The combination of claim 32 wherein one of said primary control loops is a
2 turbogenerator speed control loop.

1 35. The combination of claim 32 wherein one of said primary control loops is a power
2 control loop.

1 36. The combination of claim 32 wherein said primary control loops include a turbine
2 exhaust gas temperature control loop and a turbogenerator speed control loop.

1 37. The combination of claim 32 wherein said primary control loops include a turbine
2 exhaust gas temperature control loop and a power control loop.

1 38. The combination of claim 32 wherein said primary control loops include a power
2 control loop and a turbogenerator speed control loop.

1 39. The combination of claim 32 wherein said primary control loops include a turbine
2 exhaust gas temperature control loop, a turbogenerator speed control loop, and a power control
3 loop.

1 40. The combination of claim 39 wherein said turbine exhaust gas temperature control
2 loop and said turbogenerator speed control loop command fuel output to the turbogenerator
3 combustor.

1 41. The combination of claim 40 and in addition a selector to select the minimum fuel
2 command from said turbine exhaust gas temperature control loop and said turbogenerator speed
3 control loop.

1 42. The combination of claim 39 wherein said controller additionally includes a
2 turbogenerator speed command control loop and a turbogenerator power command control loop.

1 43. The combination of claim 39 wherein said controller additionally includes a maximum
2 turbogenerator speed control loop and a maximum turbine exhaust gas temperature control loop.

1 44. The combination of claim 31 wherein said processor utilizes a once per pumping cycle
2 signal generated by each pump-jack oil well that is powered by a given turbogenerator to
3 synchronize historical inverter frequency versus time data with that pump-jack oil well's pumping
4 cycle position.

1 45. The combination of claim 31 wherein said processor utilizes shift registers to store the
2 average low frequency/load inverter frequency data in a manner that is frequency and phase
3 locked to the pumping cycle of each pump-jack oil well being powered by a given turbogenerator.

1 46. The combination of claim 31 wherein said processor computes the average historical
2 frequency of the low frequency load inverter for any point within a pumping cycle for any given
3 pump-jack oil well being powered by a turbogenerator.

1 47. The combination of claim 31 wherein said processor computes the best or nearly best
2 frequency for the low frequency load inverter at any point in time so as to minimize the variations
3 in turbogenerator/motor power requirements when one or more pump-jack oil wells are powered
4 by that turbogenerator and does so based on historical frequency versus time data for the low
5 frequency load inverter and once per pump/cycle signals from all pump-jack oil wells powered by
6 that turbogenerator.

1 48. The combination of claim 31 wherein said processor includes a frequency computer
2 for each pump-jack oil well supplied with electrical power by said permanent magnet
3 turbogenerator/motor, said frequency computer receiving a once per pump cycle signal from its
4 associated pump-jack oil well and computing the best frequency for the low frequency load
5 inverter.
6

1 49. The combination of claim 48 wherein said processor additionally includes an averager
2 to receive the computed frequencies from said frequency computer for each pump-jack oil well
3 and to produce a compromise frequency for each pump-jack oil well.

1 50. The combination of claim 48 wherein each frequency computer includes a plurality of
2 inverter pulse registers

1 51. The combination of claim 48 wherein each frequency computer includes a plurality of
2 inverter pulse registers and a plurality of motor slip pulse registers.

1 52. The combination of claim 48 wherein each frequency computer includes a plurality of
2 inverter pulse registers and a plurality of motor slip pulse registers.

1 53. In combination:

2 a permanent magnet turbogenerator/motor including a permanent magnet
3 generator/motor, a compressor, and a gas turbine having a combustor;

4 a plurality of pump-jack oil wells each driven by an electric induction motor supplied with
5 electrical power by said permanent magnet turbogenerator/motor; and

6 a controller operably associated with said permanent magnet turbogenerator/motor and
7 each of said plurality of pump-jack oil wells to establish a variable frequency time profile for said
8 electric induction motor of each of said plurality of pump-jack oil wells, said controller utilizing
9 pump-jack oil well cycle position data and historical data on the variable frequency versus pump-
10 jack oil well cycle position profile of each of said plurality of pump-jack oil wells to provide a
11 substantially constant power level requirement for said permanent magnet turbogenerator/motor.

12 54. The combination of claim 53 wherein said variable frequency time profile is
13 established by four control loops, one control loop providing a temperature safety limit, one
14 control loop providing a speed safety limit, one control loop providing a power variation
15 minimizing control based on instantaneous data and one providing power variation minimizing
16 control based on historical data.

1 55. A method of controlling a system including a permanent magnet
2 turbogenerator/motor and a repetitive axial motion machine driven by an electric motor,
3 comprising the steps of:

4 providing electrical power from said permanent magnet turbogenerator/motor to said
5 electric motor of said repetitive axial motion machine;

controlling said permanent magnet turbogenerator/motor and said repetitive axial motion machine to establish a variable frequency time profile for said electric motor of said repetitive axial motion machine; and

utilizing repetitive axial motion machine cycle position data and historical data on the variable frequency versus repetitive axial motion machine cycle position profile to provide a substantially constant power level requirement for said permanent magnet turbogenerator/motor during current repetitive axial motion cycles.

56. A method of controlling a system including a permanent magnet turbogenerator/motor and a repetitive axial motion machine driven by an electric motor, comprising the steps of:

providing electrical power from said permanent magnet turbogenerator/motor to said electric motor of said repetitive axial motion machine;

controlling said permanent magnet turbogenerator/motor and said repetitive axial motion machine to establish a variable frequency time profile for said electric motor of said repetitive axial motion machine; and

utilizing instantaneous data on power together with historical data on power to provide a substantially constant power level requirement for said permanent magnet turbogenerator/motor during current repetitive axial motion cycles.

57. A method of controlling a system including a permanent magnet turbogenerator/motor and a plurality of repetitive axial motion machines each driven by an electric motor, comprising the steps of:

providing electrical power from said permanent magnet turbogenerator/motor to said electric motor of each of said plurality of repetitive axial motion machines;

6 controlling said permanent magnet turbogenerator/motor and said plurality of repetitive
7 axial motion machines to establish a variable frequency time profile for said electric motor of each
8 of said plurality of repetitive axial motion machines; and

9 utilizing repetitive axial motion machine cycle position data and historical data on the
10 variable frequency versus repetitive axial motion machine cycle position profile to provide a
11 substantially constant power level requirement for said permanent magnet turbogenerator/motor
12 during current repetitive axial motion cycles.

1 58. The combination of claim 57 wherein said variable frequency time profile is
2 established by four control loops, one control loop providing a temperature safety limit, one
3 control loop providing a speed safety limit, one control loop providing a power variation
4 minimizing control based on instantaneous data and one providing power variation minimizing
5 control based on historical data.

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